

# Improving Formulation of Marine Stable Boundary Layers Using CBLAST Weak Wind Data

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Grant #: N00014-05-1-0032

<http://blg.oce.orst.edu/cblast-weakwind>

## LONG-TERM GOAL

The long-term goals are to better understand air-sea exchange of momentum, heat and moisture and its impact on the marine boundary layer and to better understand the influence of SST variations on the area-averaged (grid-averaged) flux-gradient relationship. Substantial modification of the formulation of the surface moisture flux for all conditions and the boundary layer for very stable conditions are also long term goals.

## OBJECTIVES

The objectives are to quantify the influences of surface heterogeneity and strong stability on the transfer coefficients for the bulk formula and to formulate the difference between the transfer coefficients for momentum, heat and moisture.

## APPROACH

Analyze the LongEZ eddy-correlation data in the CBLAST Weak Wind Experiment 2001 and compare with eddy-correlation data from the CBLAST WHOI ASIT tower during the intensive period and prior to the intensive period. LongEZ data from SHOWEX will be incorporated for comparison. We will also analyze eddy-correlation data collected by the CIRPAS Pelican during the CBLAST Weak Wind Experiment. The analyzed fluxes will be used for evaluation of regional modeling and LES simulations.

## WORK COMPLETED

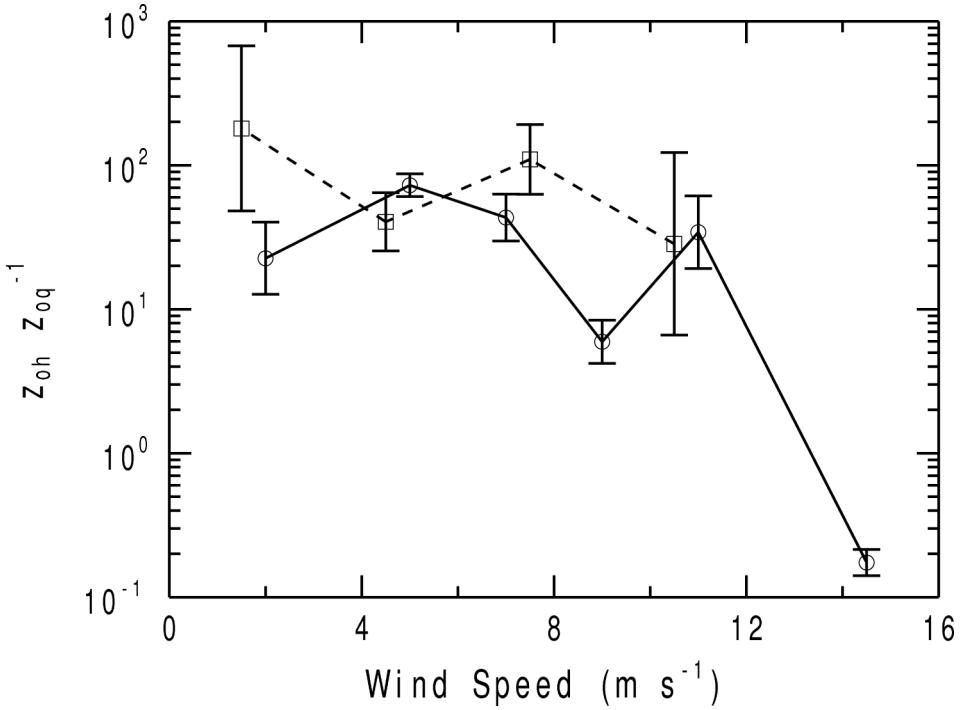
Studies on the impact of SST variations were continued. The bulk formula was evaluated using the LongEZ pilot experiment. A number of corrections were made to the Pelican data although some difficulties remain. Analysis of the ASIT tower data began.

## RESULTS

A bulk flux model with no wave state information, similar to that used to parameterize air-sea fluxes in most large scale atmospheric models, was evaluated using the aircraft data in CBLAST Weak Wind, as well as supplementary data from SHOWEX. While we cannot rule out the possibility that the

<b>Report Documentation Page</b>			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE <b>30 SEP 2005</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2005 to 00-00-2005</b>		
4. TITLE AND SUBTITLE <b>Improving Formulation of Marine Stable Boundary Layers Using CBLAST Weak Wind Data</b>			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Oregon State University,College of Oceanic and Atmospheric Sciences,Corvallis,OR,97331</b>			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>				
13. SUPPLEMENTARY NOTES <b>code 1 only</b>				
14. ABSTRACT <b>The long-term goals are to better understand air-sea exchange of momentum, heat and moisture and its impact on the marine boundary layer and to better understand the influence of SST variations on the area-averaged (grid-averaged) flux-gradient relationship. Substantial modification of the formulation of the surface moisture flux for all conditions and the boundary layer for very stable conditions are also long term goals.</b>				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	18. NUMBER OF PAGES <b>4</b>	19a. NAME OF RESPONSIBLE PERSON

measurements underestimate surface fluxes, the differences between bulk and observed latent heat fluxes appear to be too large to be fully explained by measurement problems.



**Figure 1:** Bin-averaged observed 4-km scalar roughness length ratio ( $z_{oh}$  divided by  $z_{0q}$ ) as a function of the 10-m wind speed for combined LongEZ CBLAST and SHOWEX data. ASIT data is denoted by the dashed curve with squares.

With weak to moderate winds, the observed fluxes of latent heat were systematically smaller than predicted by the model. The more efficient transfer of heat compared to moisture for weak to moderate winds, as reflected by the roughness lengths (Figure 1), is consistent with the increased importance of temperature, as compared to moisture, in the buoyancy generation of turbulence in these datasets. The ratio of the thermal roughness length to that for moisture is of order 10 except for the strongest wind speed conditions associated with wave breaking, where it decreases to order 0.1. The enhanced moisture flux over breaking waves is coincident with strong advection of cold dry air from the continent.

The momentum, sensible heat and latent heat fluxes respond strongly to SST changes which exceed 1 C in amplitude on the 8-km scale (difference between two adjacent 4-km averages of SST). When the change in SST is less than this value, the response of the fluxes is not significant. A larger number of repeat passes over the same SST feature would be required to extend this analysis to shorter scales. A case study of flow from cold to warm water shows that acceleration of the low-level mean wind over the warm pool appears to be related to the decrease in vertical stress divergence associated with a much deeper boundary layer over the warm water.

## PUBLICATIONS

Mahrt, L., D. Vickers, W. Drennan, H. Graber and T. Crawford, 2005: Fluxes measured from moving platforms. *J. Atm. and Oc. Tech.* 22, 857-865. [published, refereed]

Vickers, D. and L. Mahrt, 2004: Atmospheric response to sea-surface temperature variability. 16th Boundary Layer -Turbulence Conference. American Meteorological Society. Portland, Maine, August 2004.

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